Modeling the Directional Spectral Radiative Properties of Semitransparent Wafers with Thin-Film Coatings

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In a recent work, a Monte Carlo method was applied to simulate the radiative processes in a semitransparent silicon wafer with one or both surfaces being rough [1]. This allows the prediction of the spectral radiative properties of the wafer, including bidirectional reflectance and transmittance and directional absorptance and emittance. The surface slope distribution was used with a micro-facet model to determine the direction of reflected and refracted rays. The absorption inside the wafer was considered using the temperature- and wavelength-dependent optical constants of silicon.

Many of the semitransparent materials have coatings, such as silicon oxides, nitrides, and/or metallic thin films on one or both surfaces. In the present study, we study the effect of coating on the radiative properties of semitransparent materials with rough surfaces. The coating is treated as coherent and results in a modification of the reflection and transmission coefficients. On the other hand, the wafer substrate is assumed to be much thicker than the coating; therefore, radiation inside the wafer can be treated as incoherent.

The micro-facet model used only one statistical parameter, which may result in unrealistic estimation of the directional radiative properties at large reflection angles. The method of generating a stochastic surface is also employed to include both the autocorrelation length and surface height distribution. Tang et al. [2] used this method to predict the bidirectional reflectance for opaque substrates with and without a coating. In the present work, both surfaces need to be considered because the substrate is semitransparent. An effort will be made to compare the numerical methods with experimental results.

1. Zhou, Y.H., and Zhang, Z.M., "Radiative Properties of Semitransparent Silicon Wafers with Rough Surfaces," accepted for publication in Journal of Heat Transfer (2002).
2. Tang, K., Kawka, P. A., and Buckius, R. O., 1999, "Geometric Optics Applied to Rough Surfaces Coated with an Absorbing Thin Film," J. Thermophys. Heat Transfer, 13(2), 169-176 (1999).

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